PHILIPS

Single-trace miniature oscilloscope

PM3000

Dual-trace miniature oscilloscope

PM3010

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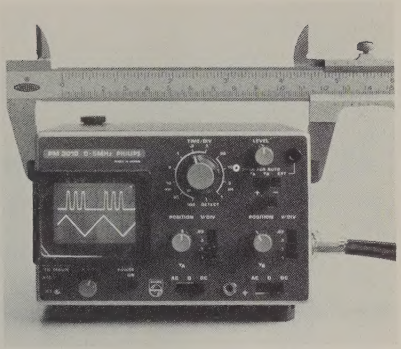

Operating manual

Single-trace miniature oscilloscope

PM 3000

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PM 3010

9499 440 12811 74/02/15/1/01

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Fig. 1.1. A truly portable instrument that can be carried as easily as a camera

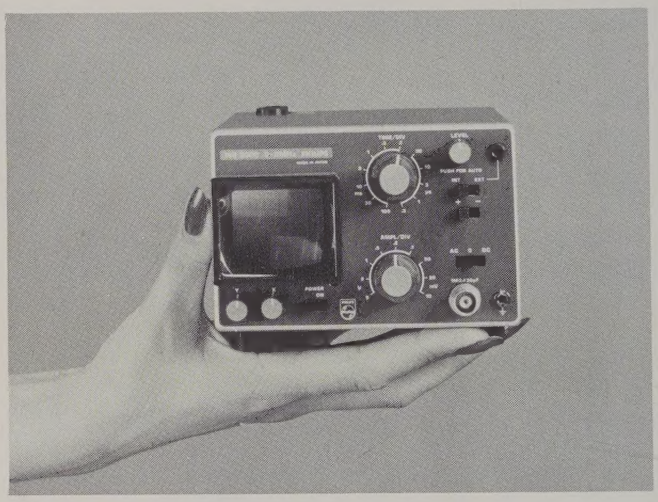


Fig. 1.2. Single-trace oscilloscope PM 3000

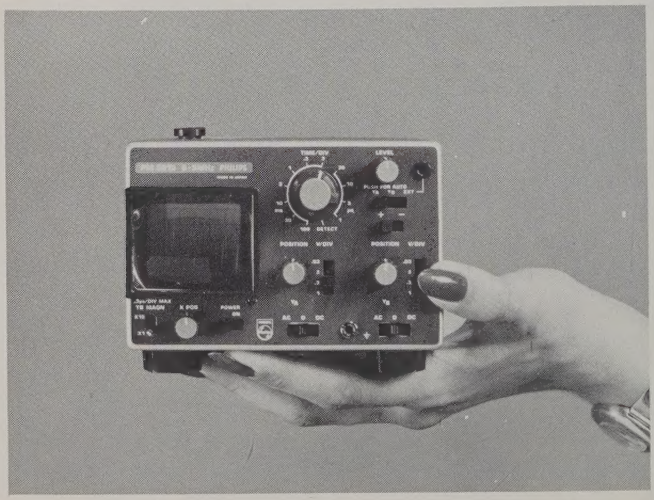


Fig. 1.3. Dual-trace oscilloscope PM 3010

1. GENERAL INFORMATION

1.1. INTRODUCTION

The PHILIPS single and dual-trace miniature oscilloscopes PM 3000 and PM 3010 have been designed as instruments that can be carried as easily as cameras.

Each instrument is supplied with an ever-ready case with strap. This enables the instrument to be in operation while carried around the user's neck, leaving both his hands free.

The miniature oscilloscopes can be operated by a rechargeable lead-acid battery or powered from the mains.
This, together with a 5 MHz bandwidth (−3 dB) and a high sensitivity, makes the instruments suitable for a variety of applications.

1.2. CHARACTERISTICS

Designation		Specification	Additonal information
1.2.1.	C.r.t.		
	Type	40DB31	Medium persistence phosphor
	Display area	4 x 6 divisions	1 div = 4,5 mm A removable magnifying lens enlarges the display by approx. 1,3 times.
	Graticule	Internal	Not illuminated
	Acceleration voltage	1,5 kV	
1.2.2.	**Vertical or Y axis**		
1.2.2.1.	*Response*		
	Frequency range	d.c. ... 5 MHz PM 3000 5 Hz ... 5 MHz PM 3010 20 Hz ... 5 MHz	–3 dB bandwidth d.c. coupled –3 dB bandwidth a.c. coupled –3 dB bandwidth a.c. coupled
	Rise time	70 ns	
1.2.2.2.	*Deflection coefficients*		
	PM 3000	10 mV/div ... 5 V/div	Nine positions in 1-2-5 sequence
	PM 3010	30 mV/div ... 1 V/div	Four positions in 1-3-10 sequence
	Error limit	±5 %	
1.2.2.3.	*Maximum permissible input voltage*	±600 V	d.c. + a.c. peak
1.2.2.4.	*Input impedance*	PM 3000 1 MOhm//30 pF PM 3010 1 MOhm//35 pF	
1.2.3.	**Time or X axis**		
1.2.3.1.	*Time coefficients*		
	PM 3000	100 ms/div ... 0,3 µs/div	Twelve positions in 1-3-10 sequence
	PM 3010	100 ms/div ... 1 µs/div	Eleven positions in 1-3-10 sequence
	Coefficient error	±5 %	
1.2.3.2.	*Expansion* (PM 3010 only)		
	Magnification	10x	Highest effective sweep speed is 0,3 µs/div
1.2.4.	**Triggering**		
1.2.4.1.	*Trigger mode*	Automatic or manual level control	
1.2.4.2.	*Trigger source*		
	PM 3000	Internal External	
	PM 3010	Internal External	Channel Y_A or channel Y_B
1.2.4.3.	*Trigger sensitivity*	Internal 0,5 div External 0,5 V	

1.2.4.4. Trigger bandwidth	30 Hz ... 5 MHz	Internal
	100 Hz ... 5 MHz	Automatic
	30 Hz ... 5 MHz	External
1.2.4.5. Input impedance	1 MOhm//50 pF	
1.2.4.6. Maximum permissible input voltage	100 V	d.c. + a.c. peak

1.2.5. Operating conditions

1.2.5.1. Supply	a.c. or d.c.	
a.c.	115, 230 V ±10 %; 50 ... 400 Hz Power consumption 11 VA	Using PM 9398
d.c.	6 V, 0,5 A	Using PM 9397 which provides up to five hours of continuous operation
1.2.5.2. Ambient temperature	+ 5 °C ... +40 °C	Rated range of use
	−10 °C ... +55 °C	Limit range of operation
	−40 °C ... +70 °C	Storage and transport conditions

1.2.6. Environmental capabilities

1.2.6.1. Vibration	30 minutes along each of the 3 major axes. 0,7 mm peak-to-peak displacement. From 10 Hz to 150 Hz constant acceleration of 50 m/s^2 (≈ 5 g)	
1.2.6.2. Shock	The oscilloscope stands 1000 bumps, each axis; 100 m/s^2 (≈ 10 g) peak acceleration at a pulse duration of 6 ms	

1.2.7. Mechanical data

1.2.7.1. Dimensions	Depth 190 mm Width 125 mm Height 81 mm	
1.2.7.2. Weight	1.8 kg	with battery PM 9397
	1.6 kg	with a.c. power supply PM 9398

1.3. ACCESSORIES

1.3.1. Standard accessories delivered with the instrument

- Magnifying lens, enlarging the display by approx. 1,3 times
- A.C. Power supply PM 9398 which fits both PM 3000 and PM 3010
- Carrying case
- Operating manual

1.3.2. Optional accessories

- Rechargeable sealed lead-acid battery PM 9397.
  The battery supplies 6 V/3 Ah and provides up to 5 hours of continuous operation.
- Passive probe set PM 9326 with a 10:1 and a 1:1 probe; cable length 1,15 m.
- Passive 1:1 probe PM 9335
- Passive 10:1 probe PM 9336; cable length 1,5 m.
- Passive 10:1 probe PM 9336L ; cable length 2,5 m.

Fig. 1.4. A.C. Power supply PM 9398

Fig. 1.5. Carrying case

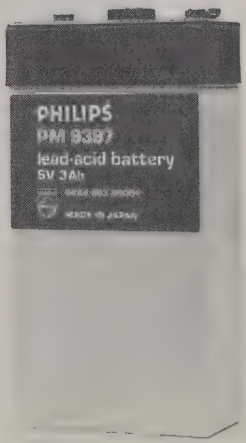


Fig. 1.6. Lead-acid battery PM 9397

1.4. DESCRIPTION OF THE BLOCK DIAGRAM

1.4.1. Y Axis

The oscilloscope PM 3000 has a d.c. coupled vertical amplifier. This amplifier comprises an input step-attenuator, a source follower with protection circuitry, a pre-amplifier stage and an output stage.
The protection circuit prevents damage to the input field-effect transistor in case of too high an input voltage.
The output stage couples the signal to the c.r.t. and also supplies part of the signal to the trigger pre-amplifier if internal triggering is used.

1.4.2. Triggering

A triggering signal can be obtained internally from the vertical amplifier or from an external source.
The triggering signal is fed to a trigger-pulse shaper which supplies well-defined trigger pulses to start the time-base generator.

1.4.3. Time-base

The time-base generator is of the constant-current integrator type and supplies three output voltages.
These are a sawtooth voltage which is fed to the horizontal output amplifier, a gate pulse which controls the unblanking of the c.r.t. during the sweep and a voltage for probe compensation, which is available on a socket at the rear of the instrument.

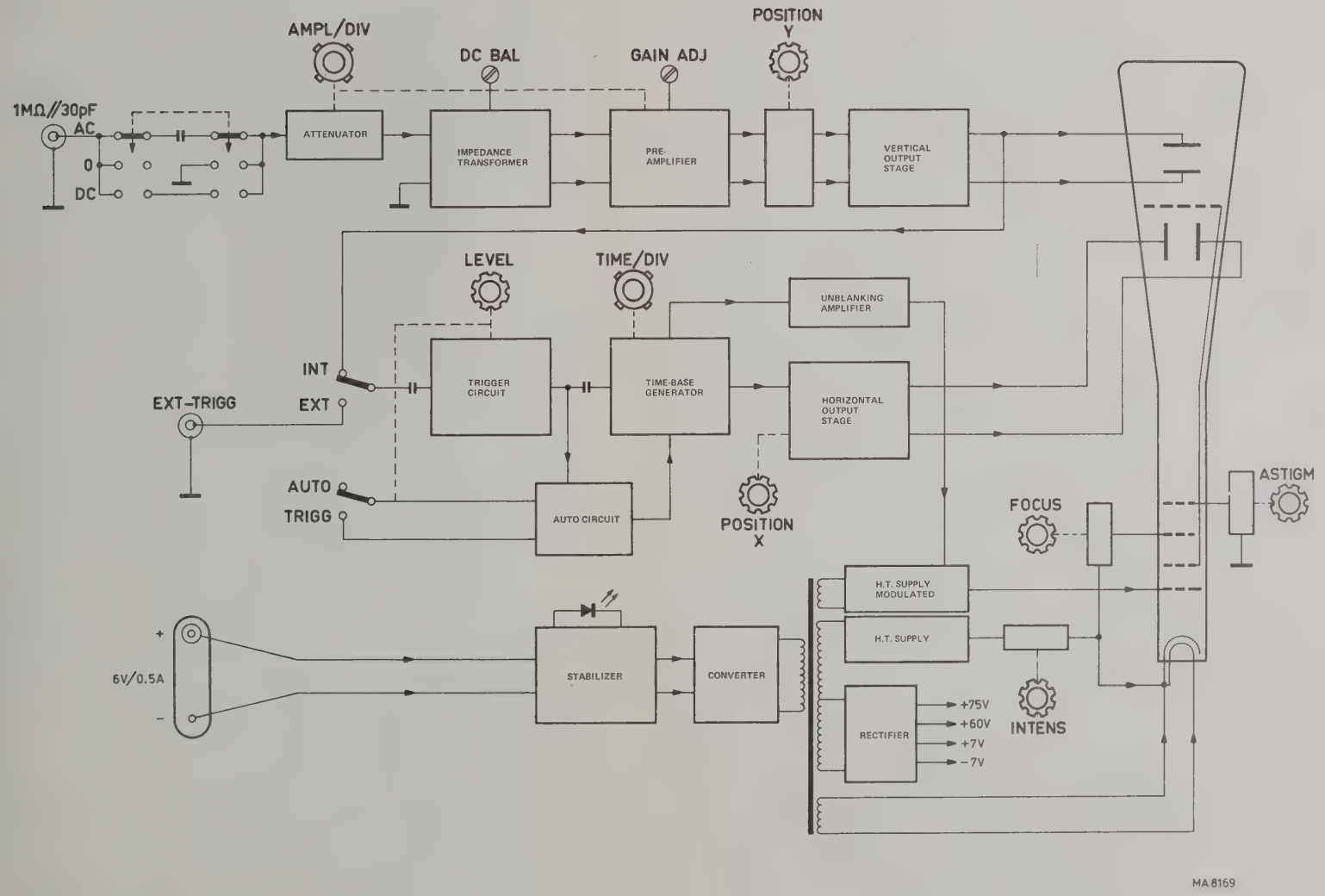


Fig. 1.7. Block diagram of single-trace oscilloscope PM 3000

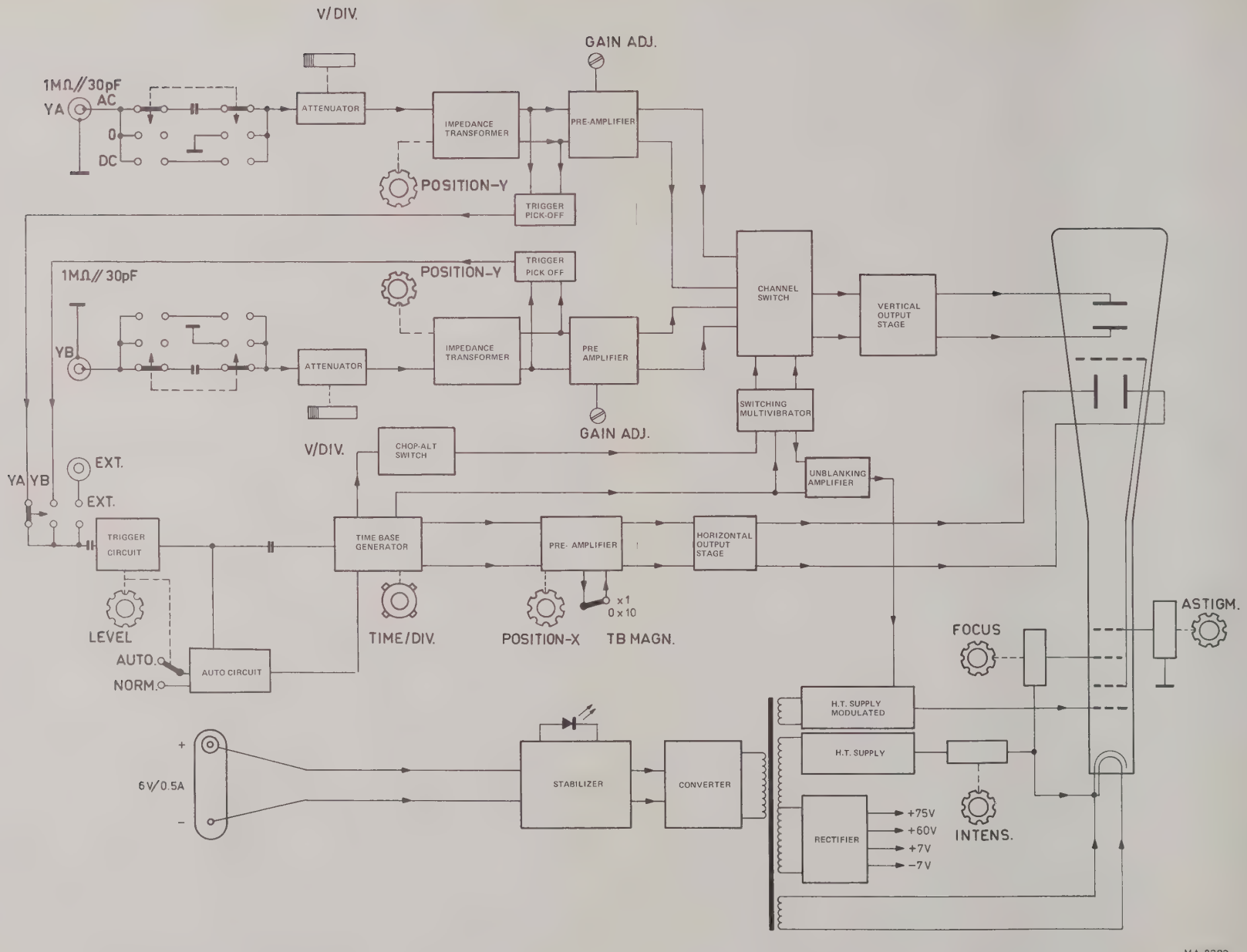


Fig. 1.8. Block diagram of dual-trace oscilloscope PM 3010

1.4.4. X Axis

The horizontal output amplifier receives its input signal from the time-base generator. From the amplifier the sawtooth voltage is fed to the horizontal-deflection plates of the c.r.t.

1.4.5. Cathode-ray tube

The c.r.t. is provided with one control for the brilliance of the trace and one for its focussing. The high voltages for the c.r.t. are generated by a converter which also delivers the other supply voltages.

1.4.6. Different circuits of dual-trace oscilloscope PM 3010

The dual-trace oscilloscope PM 3010 has two vertical channels which are similar to the one of the single-trace model PM 3000, except for an extra trigger pick-off stage. An electronic switch between the Y pre-amplifiers and the Y output amplifier allows simultaneous display of the input signals of both channels, by switching the display from one vertical channel to the other. The electronic switch operates in the chopped mode, i.e. at a fixed frequency of 100 kHz at time coefficients 3, 30 and 100 μs/div. At the other time coefficients the switch works in the alternate mode and the display is switched over from one channel to the other at the end of every sweep.
In this oscilloscope, an extra blanking pulse is produced to suppress the beam during the time that the display is switched over in the chopped mode.

2. DIRECTIONS FOR USE

2.1. INSTALLATION

WARNING

This instrument generates high voltages and should not be operated with the covers removed. The mains plug or battery should be removed before attempting any maintenance work, and any relevant high voltage points discharged.

2.1.1. Earthing

Make sure that the instrument cabinet is properly earthed. The measuring-earth terminal at the front of the instrument is connected to the cabinet.

IMPORTANT Neither battery supply, nor supply with the double-insulated a.c. power unit PM 9398 make the instrument safe for floating measurements, since the measuring earth is connected to the metal cabinet.

2.1.2. Installing the battery PM 9397

- Remove the rear panel after unscrewing the lock screw (Direction OPEN).
- Take the terminal strip out of the battery compartment of the oscilloscope and snap it on to the battery.
- Slide the battery, terminal strip first, into the battery compartment.
- Replace the rear panel and tighten the lock screw.

2.1.3. Installation of the a.c. power supply PM 9398

- Remove the rear panel after unscrewing the lock screw (Direction OPEN).
- Take the terminal strip out of the battery compartment of the oscilloscope and snap it on to the a.c. power supply.
- Slide the power supply, terminal strip first, into the battery compartment.
- Remove the rubber stopper from the rear panel and pass the mains cable of the power supply through the hole.
- Replace the rear cover and tighten the lock screw.

Fig. 1.9. Rear view of oscilloscope powered by a.c. power supply PM 9398

2.1.4. Switching on

In case of battery supply:

Switch on the instrument by means of the POWER ON switch and check that the pilot lamp lights up.
If the pilot lamp fails to light up or if it extinguishes during use of the instrument, switch off immediately and start recharging the battery.
Continued use of the instrument with extinguished pilot light will irretrievably damage the battery.

In case of mains supply:

Check that the a.c. power supply is adjusted to the local mains voltage.
At delivery, the power supply is set for a mains voltage of 230 V.

To adapt the supply to a 115 V mains, proceed as follows:
– Remove the lid of the a.c. power supply (2 screws)
– Remove the connection wire between B and C
– Interconnect points A and C
– Interconnect points B and D
– Refit the lid

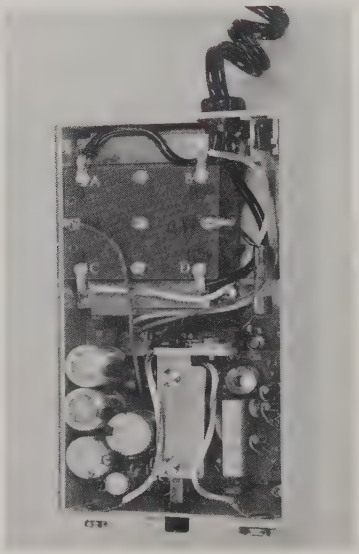


Fig. 1.10. Adjusting the a.c. power supply to a mains voltage of 115 V

2.2. OPERATING INSTRUCTIONS

Before switching on, ensure that the oscilloscope has been correctly installed in accordance with chapter 2.1. INSTALLATION, and that the precautions outlined have been observed.

2.2.1. Controls and sockets of PM 3000

At the front of the instrument (Fig. 2.1.)

TIME/DIV	Time-coefficient control of the time-base; 12-way switch.
LEVEL	Continuously variable control to select the signal level at which the time-base generator starts. Incorporates a push-pull switch to obtain automatic triggering. The automatic mode provides for a free-running time-base in the absence of triggering signals.
INT/EXT	Trigger source; 2-position switch: INT : Trigger signal derived from the Y amplifier. EXT: Trigger signal derived from a voltage applied to the adjoining trigger input socket.

Fig. 2.1. Front view of oscilloscope PM 3000

+/–	Slope control; 2-position switch: provides for triggering on either the positive-going slope or the negative-going slope of the signal.
AMPL/DIV	Control of the Y deflection coefficients; 9-way switch.
Y	Continuously variable control giving vertical positioning of the display.
X	Continuously variable control giving horizontal positioning of the display.
POWER ON	Switch connecting the secondary power to the instrument. The pilot lamp lights up when the power is switched on. **The pilot lamp failing to light up at battery supply indicates that the battery needs to be recharged.**
AC/0/DC	Signal coupling; 3-position switch: AC : via a coupling capacitor 0 : interruption of connection between input socket and input circuit, the latter being earthed, in order to display a zero-volt line DC : direct coupling
1 MOhm//30 pF	Input socket for the vertical deflection signals.

At the top of the instrument (Fig. 2.2.):

INTENS	Continuously variable control of the trace brilliance.
FOCUS	Continuously variable control of the electron-beam focussing.

At the rear of the instrument (Fig. 2.3.):

PROBE ADJ	Square-wave outlet for the compensation of probes.
CHARGE	Connector to charge the battery without taking it out of the instrument.
EXT POWER	Hole in the rear panel of the instrument through which the mains cable is passed when A.C. ADAPTER PM 9398 is used to power the oscilloscope. If the battery is used, the hole may be filled with a rubber stopper.

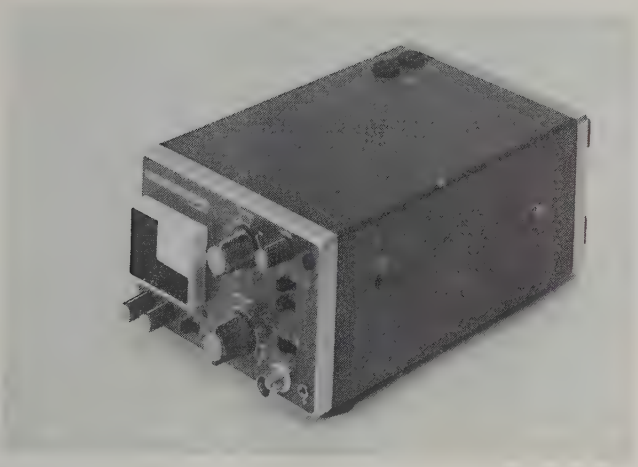


Fig. 2.2. Controls at the top of the instrument

Fig. 2.3. Rear view of the instrument

2.2.2. Controls and sockets of PM 3010

Only the controls which differ from those of the PM 3000 are dealt with in this section. For the other controls, please refer to section 2.2.1.

At the front of the instrument (Fig. 2.4.):

TIME/DIV	The time-base switch of the PM 3010 model incorporates an extra position DETECT. The use of this position is described in section 2.2.9.
YA/YB/EXT	Trigger source; 3-position switch: YA : Trigger signal derived from channel YA of the Y amplifier. YB : Trigger signal derived from channel YB of the Y amplifier EXT : Trigger signal derived from a voltage applied to the adjoining trigger input socket.
POSITION YA	Continuously variable control giving vertical positioning of the display of channel YA.
POSITION YB	Continuously variable control giving vertical positioning of the display of channel YB.
TB MAGN	Switch for 10x magnification of the time-base, the highest effective sweep-speed being 0,3 μs/div

At the right-hand side of the instrument (Fig. 2.5.):

YA	Input socket for vertical channel YA.
YB	Input socket for vertical channel YB.

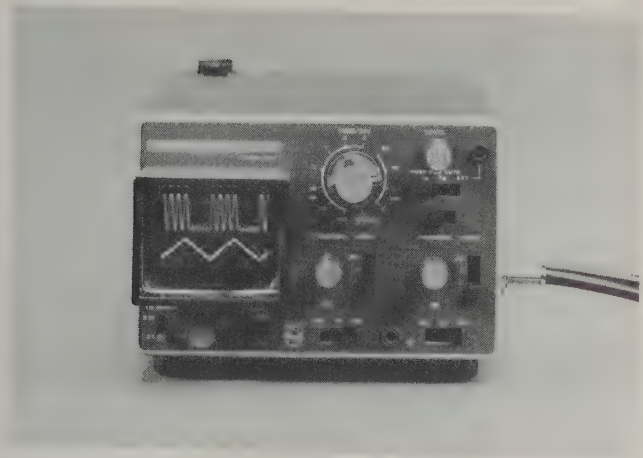


Fig. 2.4. Front view of oscilloscope PM 3010

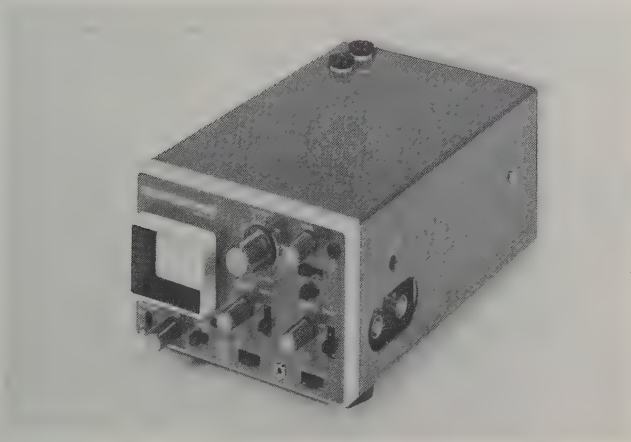


Fig. 2.5. Input sockets at the right-hand side of oscilloscope PM 3010

2.2.3. Preliminary settings

– Switch on the instrument
– AC/0/DC switch(es) to AC
– AMPL switches to maximum sensitivity
– POSITION controls to mid-range
– TIME/DIV control to 1 ms
– LEVEL control to AUTO (depressed)
– INT/EXT switch to INT
– INTENS control fully clockwise
– FOCUS control to mid-range

Extra for PM 3010:
– TRIG switch to A
– TB MAGN control to x1

NOTE: Controls not mentioned may be in any position.

The time-base line(s) should appear after approx. 10 s.
When the display is there, adjust INTENS and FOCUS for a sharp, well-defined display.

– Centre the trace(s)
– Check that the trace runs exactly in parallel with the horizontal lines of the graticule
  If necessary, readjust the TRACE ROTATION control which is a screw-driver operated potentiometer, accessible through a hole in the right-hand side panel of the oscilloscope (Fig. 2.6.).

Fig. 2.6. TRACE ROTATION control

The oscilloscope is then ready for use.

2.2.4. Measuring example

In this example we shall explain how to display a sine-wave voltage of 1 V_{p-p} at a frequency of 1 kHz. The controls of the oscilloscope are in the same position as in the previous section unless otherwise stated.

- Apply the sine-wave voltage to the Y input socket (for the PM 3010 to the YA input socket)
- AC/0/DC switch to AC
- Set the input attenuator switch to 1 V/DIV
- Rotate the LEVEL control until a stable display is obtained.

On the screen there is now the display of a sine-wave.
One cycle of the signal is one division wide and the signal height is also one division. The trace height can be increased by rotating the attenuator switch clockwise (or sliding the attenuator switch of the PM 3010 upwards), whereas the width of a cycle can be increased by turning the TIME/DIV switch clockwise.

2.2.5. Influence of the AC/0/DC switch

Depending on the composition of the Y input signal, the AC/0/DC switch should be set to position AC or DC.

In position DC the input signal is coupled direct to the Y amplifier. Because the Y amplifier is d.c. coupled, the entire bandwidth of the instrument is available. This means that the complete input voltages are fed to the deflection plates, which implies that the d.c. components result in trace shifts on the screen. This may cause difficulties when a.c. signals superimposed on high direct voltages have to be displayed. In order to make the a.c. signal visible in those cases, a greater attenuation would be necessary, with the result that the a.c. signal would also be strongly attenuated.

In this case the AC/0/DC switch can be set to position AC. Then a blocking capacitor is connected between the input socket and the Y amplifier. As a result of this, d.c. voltages are blocked, but also the lower frequencies are suppressed or attenuated. When square-wave signals of low frequency are displayed, this will result in some pulse droop.

In the 0 position of the AC/0/DC switch it is possible to quickly determine the zero volt d.c. level. In this position the connection between the amplifier input and the input socket is interrupted, the amplifier input being earthed. At the same time, the blocking capacitor is discharged to prevent damage of the circuit under test by a possible high charge.

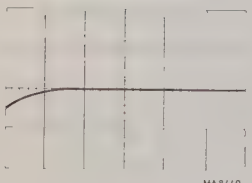
2.2.6. Loading effect of the oscilloscope input

In order to obtain a reliable measuring result, it is necessary to couple the signal to the oscilloscope input by means of a screened cable. The disadvantage of a screened cable is its relatively high capacitance. This capacitance causes a considerable drop of the input impedance of the oscilloscope at higher frequencies.
If tuned circuits are measured, the cable capacitance may also cause detuning.

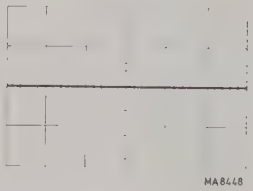
Use of a 10:1 attenuator probe is, therefore, recommended.
Such a probe has an input impedance of 10 MOhm paralleled by an input capacitance in the order of 10 pF. Bear in mind, however, that the probe attenuates all signals by a factor of 10. Thus, it is necessary to multiply the amplitude-measuring result by 10.

If use of an attenuator probe is not possible due to the attenuation, a 1:1 probe should be used.

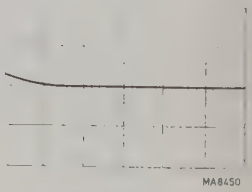
Do not forget that an attenuator probe must be matched to the particular oscilloscope it is used with. The matching procedure is as follows:
- Set the AC/0/DC switch of the oscilloscope to DC
- Set the AMPL switch to 50 mV (PM 3000) or .03 V (PM 3010)
- Set the TIME/DIV switch to 30 μs. The controls which are not mentioned are set as indicated in section 2.2.3.
- Connect the probe cable to the YA input socket and the probe tip to the PROBE ADJ socket at the rear of the instrument
- Adjust the probe as indicated in the probe manual, until a trace as shown in Fig. 2.7.2. is obtained.



Under compensated
Fig. 2.7.1.



Correctly compensated
Fig. 2.7.2.



Over compensated
Fig. 2.7.3.

Fig. 2.7. Matching the probe to the oscilloscope input

2.2.7. Triggering

2.2.7.1. General

In order to obtain a stationary trace, the horizontal deflection must always be started at a fixed point of the signal. The time-base generator is, therefore, started by narrow trigger pulses formed in the trigger unit and controlled by a signal originating from the vertical input signal or an external source.

2.2.7.2. Trigger level

In case of a complicated signal in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape so as to obtain a stationary trace. This is possible when one of the details has a deviating (larger) amplitude.
By means of the LEVEL knob the trigger level can be set in such a way that only this larger voltage variation passes this level.

2.2.7.3. Automatic triggering

Automatic triggering, when the PUSH FOR AUTO switch is depressed, is most often used on account of its simple operation. In this mode it is possible to display a large variety of waveforms having different amplitude and shape, without the necessity to operate any of the trigger controls.

If no triggering signal is present, a time-base line remains visible on the screen. This is useful for zero reference purposes.

NOTE: Signals with a frequency of 100 Hz or lower must not be displayed in the AUTO mode, since the lower frequency limit of the auto-circuit is 100 Hz. The display of such signals would be very unstable.

2.2.7.4. External triggering

External triggering is important to obtain a stationary display in case of complex signals and pulse patterns, when a more simple signal at a related frequency is available.
External triggering is also useful if signals are measured having a strongly varying amplitude, if a signal with a fixed amplitude and equal frequency is available. The necessity of readjusting the level setting at every variation of the input signal is then obviated.

2.2.8. **Time-base magnifier** (for PM 3010 only)

The magnifier is operated with a toggle switch. When this switch is in the x10 position, the time-base sweep speed is increased 10 times. In this position the sweep time is determined by dividing the indicated TIME/DIV value by 10. Bear in mind that the maximum effective sweep speed is 0,3 μs/DIV. Each part of the expanded trace can be made visible by means of the X POSITION control.

2.2.9. DETECT position of the time-base switch

When the time-base switch occupies the DETECT position, the horizontal deflection is disconnected from the time-base generator and a dot appears on the screen, provided that the LEVEL control is not in the AUTO position.
In the DETECT position it is possible to detect a narrow pulse by connecting the signal to one of the input sockets and setting the trigger-source switch to the relevant channel.
The LEVEL control must be used to find the most sensitive position.

As soon as the pulse occurs, the dot jumps to a different position on the screen, the positions of the dot depending upon the setting of the Y POSITION controls. Upon arrival of the next pulse, the dot jumps back to its original position. In this way it is possible to determine the presence of a once occurring pulse at a certain time, which would be impossible using the normal time-base.

2.3. RECHARGING BATTERY PM 9397

The battery must be recharged by a.c. power supply PM 9398 only. As the power supply has been designed specially for operating the miniature oscilloscope and for recharging battery PM 9397, it is not recommended to use it for the charging of other battery types.

2.3.1. Recharging procedure

– Connect battery and a.c. power supply as shown in Fig. 2.8. Make sure that the switch on the a.c. power supply is actuated by the battery.

IMPORTANT Interconnect battery and power supply before connecting the power supply to the mains.
In this way, uncontrolled high switching currents, which may damage both power supply and battery, are prevented.

– Connect the a.c. power supply to the mains and check that the pilot lamp lights up.
– Recharging has been completed when the pilot lamp on the a.c. adapter starts blinking.

– During charging, keep both battery and a.c. adapter on a level surface. The ambient temperature for recharging should be 0° ... 40 °C.

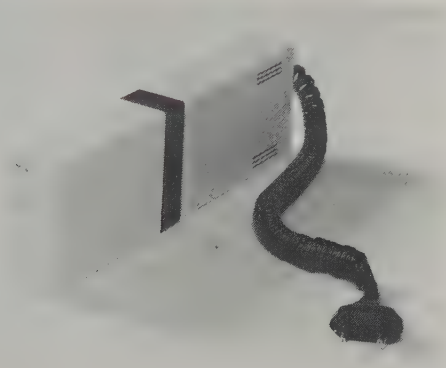


Fig. 2.8. Interconnection of battery and power supply for charging

The need for recharging of the battery is indicated by the pilot lamp of the oscilloscope in which the battery is used. When this lamp extinguishes during operation, the battery must be recharged immediately. When the battery is used after the pilot lamp has extinguished, it will be irretrievably damaged.

2.3.2. Precautions to be taken when using, charging and storing battery PM 9397

– The battery has been designed to match the characteristics of the miniature oscilloscopes PM 3000 and PM 3010.
Therefore, it should not be used to power other electrical instruments or appliances.
– Only use the a.c. power supply PM 9398 to charge the battery, as its circuitry has been designed to match the battery characteristics. If a different type of battery charger is used, the battery may be over- or undercharged and its life drastically shortened.
With the PM 9398 the battery cannot be overcharged.
– Make a habit of recharging the battery immediately after use. The best way to keep the battery in tip-top condition is to keep it fully charged.
– Do not leave the instrument switched in overnight if it is powered by the battery. The battery discharges in approximately 5 hours of continuous use to a safe level. If this level is exceeded by discharging the battery further, it will be over-discharged and irretrievably damaged.

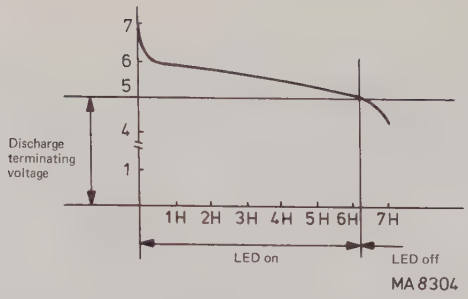


Fig. 2.9. Discharge curve of the battery
(voltage in Volts as a function of time in Hours)

- Store the battery preferably at an ambient temperature between −15 °C and +20 °C. At a higher temperature, the chemical reaction in the electrolyte and thus the self-discharging is accelerated.
- During extended storage, occasional charging of the battery is necessary. To avoid over-discharge during storage, we recommend to charge stored batteries once every three months.
- Do not short-circuit the battery terminals. This causes a current of over 100 A to flow and the terminals will be severely burned. Recently charged batteries may even explode due to the oxygen and hydrogen produced in the charging proces.

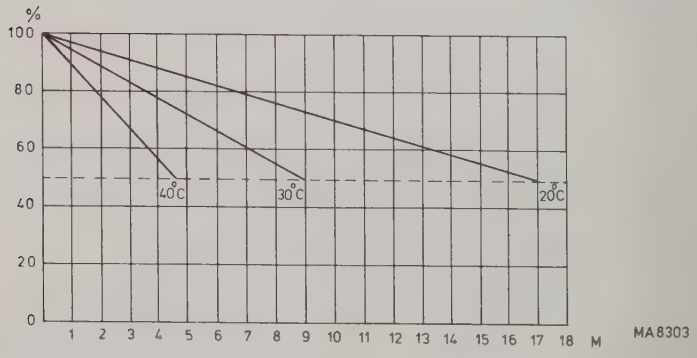


Fig. 2.10. Self-discharging of the battery
(charge in % of maximum charge as a function of time in Months)

- If the battery case is broken, hands and clothes may come into contact with the electrolyte. The best neutralizing agent for the electrolyte is sodium carbonate (Na_2CO_3). If the latter is not available, the hands and clothes must be thoroughly washed with water and soap.
- Never use paraffin oil or thinner to clean the battery case. Always use a soft cloth dampened with denatured alcohol or water. Afterwards wipe the case with a dry cloth.

2.4. SOME BASIC CONCEPTS AND DEFINITIONS

2.4.1. Y deflection coefficient or sensitivity (V/cm or V/div)

Indicates the peak-to-peak value of the input voltage to bring about a deflection of the beam over a distance of 1 cm or 1 division in vertical direction.

2.4.2. Bandwidth or frequency range (Hz)

See Fig. 2.11.

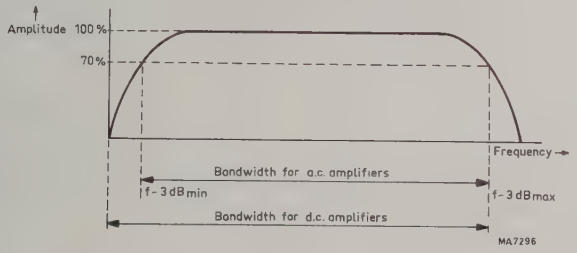


Fig. 2.11. Frequency-response curve

This is the complete range of frequencies for which the deflection coefficient does not change more than 3 dB (approx. 30 %) with respect to the flat part of the frequency-response curve, this flat part being straight between the turn over points. Beyond the −3 dB points, the response curve of the amplifier rolls off with 6 dB per octave to ensure an optimum pulse response.

2.4.3. **Pulse rise time or fall time** (ns)

See Fig. 2.12.

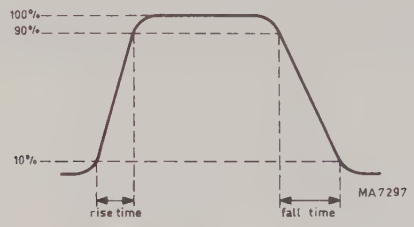


Fig. 2.12. Pulse rise and fall time

The time interval within which the voltage or current of the edge of a rectangular pulse passes from 10 % to 90 % (90 % to 10 %) of its full amplitude.

When amplifiers have a proper pulse response, the following relation between rise time (t_r) and −3 dB bandwidth (BW) is approximately true:

t_r (ns) . BW (MHz) = 350

2.4.4. **Overshoot** (%)

See Fig. 2.13.

Overshoot is that part of the initial response which exceeds the steady-state value of the response to a rectangular pulse. It is expressed as a percentage of the steady-state value.

$$\text{Overshoot} = \frac{\Delta A}{A} \cdot 100\ \%$$

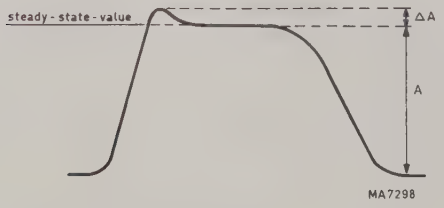


Fig. 2.13. Overshoot

2.4.5. Pulse tilt, also known as droop or sag (%)

See Fig. 2.14.

This is the difference between the initial and the final amplitude of the representation of a rectangular pulse or square-wave, ignoring overshoot and other distortions.
It is expressed as a percentage of the initial amplitude and for a specified pulse duration.

$$\text{Pulse tilt} = \frac{\Delta A}{A} \cdot 100\ \%$$

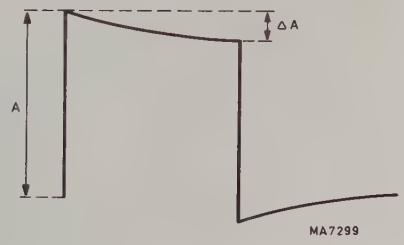


Fig. 2.14. Pulse tilt

2.4.6. Other pulse distortions

See Figs. 2.15. & 2.16. & 2.17.

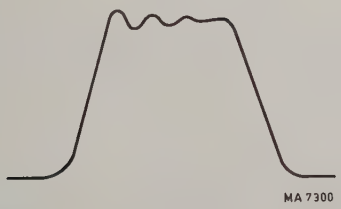


Fig. 2.15. Ringing

Fig. 2.16. Preshoot

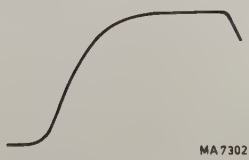


Fig. 2.17. Rounding

2.4.7. Pulse duration or width and repetition time

See Fig. 2.18.

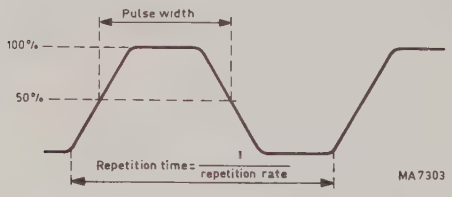


Fig. 2.18. Pulse width

2.4.8. Input impedance (MOhm//pF)

The input impedance is the final value calculated by combining the input resistance and capacitance in parallel.

2.4.9. Triggering

Triggering is the action of starting each individual sweep of the time-base by means of a control voltage.
When there is no control voltage the time-base generator remains in a waiting position and no trace is visible on the screen. Triggering can be either periodical or irregular.

In the triggered mode, any value of the time coefficient can be chosen, independent of the period of the observed quantity and without affecting the stability of the display. Triggering has also the advantage that the time-base can be calibrated.

2.4.10. Hold-off circuit

This is a circuit incorporated in the time-base generator.
It prevents the sweep from being retriggered until the spot has returned to its rest position and the circuit elements have completely relaxed.

2.5. APPLICATIONS

In the following we describe the procedure and technique for basic measurements with a PM 3000 and PM 3010 oscilloscope.

2.5.1. Voltage measurements

Display the waveform as large as possible in order to obtain maximum accuracy. When a 10:1 attenuator probe is used, observe that the displayed amplitude must be multiplied by a factor 10. Ensure that the probe is adjusted for good step response (= matched to the input capacitances of the oscilloscope); also refer to section 2.2.6.

2.5.1.1. Peak-to-peak voltage measurements

To measure the peak-to-peak value of the a.c. component of a waveform, display the signal as described in section 2.2.4. Set the input attenuator switch to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/DIV switch to display a few cycles of the waveform as illustrated in Fig. 2.19.
2. Adjust the Y POSITION control so that the lower peaks of the waveform coincide with the nearest horizontal graticule line.
3. Measure the vertical distance between the peaks of the signal.

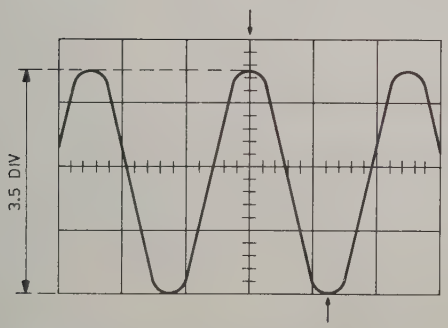


Fig. 2.19. Measuring a peak-to-peak value

4. Multiply the measured distance by the voltage setting of the attenuator switch and by the attenuation factor of the probe, if any.

Example: Assume that the attenuator switch is set to 1 V/DIV and a 10:1 attenuator probe is used.
The measured vertical distance is 3,5 DIV.
$V_{p\text{-}p}$ = vertical distance . attenuator setting . probe attenuation
= 3,5 . 1 . 10 = 35 V
If the waveform is purely sinusoidal, the r.m.s. value is

$$V_{r.m.s.} = \frac{V_{p\text{-}p}}{2\sqrt{2}} = \frac{35}{2\sqrt{2}} = 12{,}4 \text{ V}$$

2.5.1.2. Instantaneous voltage measurements

To measure the instantaneous value of a waveform, connect the signal to the Y input socket and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the AC/0/DC switch to 0 and adjust the Y POSITION control so that the zero reference line coincides with the nearest horizontal graticule line. THE Y POSITION CONTROL MUST NOT BE MOVED ONCE THIS REFERENCE LINE HAS BEEN ESTABLISHED.
2. Set the AC/0/DC switch to DC.
3. If desired, rotate the X POSITION control so that the point to be measured lies on the vertical centre line.
4. Measure the vertical distance between this point and the zero reference line. If the point lies above the reference line the voltage is positive; if the point lies below the line the voltage is negative.
5. Multiply the measured distance by the voltage setting of the attenuator switch and the attenuation factor of the probe, if any.

Example: Assume that the attenuator switch is set to 100 mV/DIV and that a 10:1 attenuator probe is used. The measured vertical distance is 3,5 DIV (see Fig. 2.20.).

V_{inst} = vertical distance . attenuator setting . probe attenuation
= 3,5 . 10^{-1} . 10 = 3,5 V, of negative polarity.

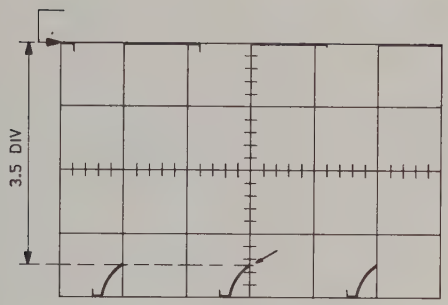


Fig . 2.20. Measuring an instantaneous value

TO MEASURE A VOLTAGE LEVEL WITH RESPECT TO ANOTHER VOLTAGE RATHER THAN TO EARTH, APPLY THE REFERENCE VOLTAGE TO THE INPUT SOCKET. ADJUST THE Y POSITION CONTROL SO THAT THE TRACE COINCIDES WITH A HORIZONTAL GRATICULE LINE WHICH CAN THEN BE USED AS A REFERENCE LINE.
THIS REPLACES THE ZERO REFERENCE PROCEDURE DESCRIBED IN STEP 1.

WARNING Bear in mind that the instrument is not safe for floating measurements, since the measuring earth is connected to the metal cabinet.

2.5.2. Time and frequency measurements

2.5.2.1. Time measurements

To measure the time interval between two points of a waveform, connect the signal to the Y input socket and adjust the Y controls to obtain as large a trace as possible. Then proceed as follows:

1. Set the TIME/DIV switch so that the horizontal distance between the time-measuring points is as large as possible.
2. Rotate the X POSITION control so that one of the measuring points coincides with the nearest vertical graticule line.
3. Rotate the Y POSITION control to bring the other point to the horizontal centre line.
4. Measure the horizontal distance between the two time-measuring points.
5. Multiply the measured distance by the TIME/DIV setting (for PM 3010 only: if magnification is used, divide this product by 10).

Example: Assume that the TIME/DIV setting is 10 ms.
The measured distance is 3,8 DIV (Fig. 2.21.).
Time interval = Horizontal distance . TIME/DIV setting
$= 3{,}8 \,.\, 10^{-2} = 38$ ms
The same display for a PM 3010 where the x10 magnifier is used would represent a time interval of $\frac{38}{10} = 3{,}8$ ms

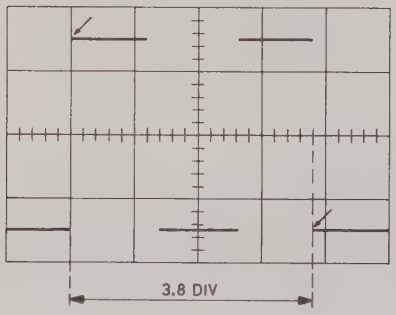


Fig. 2.21. Measuring a time-interval

After the time duration of one cycle has been estabilished in the way described above, the frequency can easily be calculated.

$$\text{Frequency} = \frac{1}{\text{time duration of one cycle}}$$

2.5.2.2. Rise-time measurements

Rise time t_r is defined as the time required by the leading edge of the signal to rise from 10 % to 90 % of the amplitude.
When the oscilloscope rise time is comparable with that of the signal under test, the actual rise time should be calculated as follows:

$$\text{actual } t_r = \sqrt{(\text{measured } t_r)^2 - (\text{oscilloscope } t_r)^2}$$

This calculation is not necessary when the signal rise time is longer than 210 ns (the error is then 5 % and decreases rapidly when the rise time becomes longer).

To measure the rise time of a waveform, connect the signal to the Y input socket and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/DIV switch to display the entire step on the screen.
2. Adjust the X POSITION control so that the 10 % point coincides with the nearest vertical graticule line; this now is the reference line and no further adjustment of the X POSITION control must be made.
3. Measure the horizontal distance between the time-reference line (coincident with the 10 % point) and the 90 % point.
4. The rise time is given by the product of the horizontal distance in DIV and the TIME/DIV setting. If the time-base magnifier is used (for PM 3010 only) this product must be divided by 10.

Example: Assume that the TIME/DIV setting is 1 μs and that the 10x magnifier is used (only the PM 3010 is equipped with a magnifier; for the PM 3000 the division by the magnification factor must be neglected).
The measured distance is 1,6 DIV (see Fig. 2.22.).

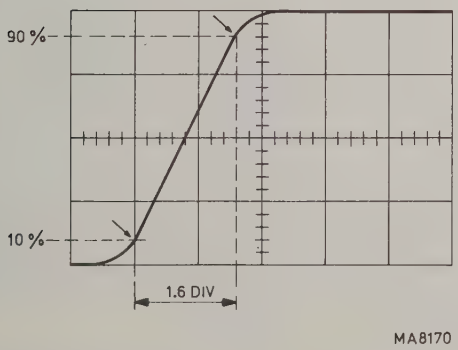


Fig. 2.22. Measuring a rise-time

$$\text{Rise time} = \frac{\text{TIME/DIV setting . horizontal distance}}{\text{magnification factor}}$$

$$= \frac{10^{-6} \cdot 1{,}6}{10} = 160 \text{ ns}$$

This is the measured rise time. As the rise time of the oscilloscope is 70 ns, we must substitute the measured rise time in the formula:

$$\text{actual rise time} = \sqrt{(\text{measured } t_r)^2 - (\text{oscilloscope } t_r)^2}$$

$$= \sqrt{160^2 - 70^2} = \sqrt{20700} = 144 \text{ ns}$$

For the measurement of fast rise times, it is useful to start the time-base generator by means of a pre-pulse applied to the external trigger input. The time relation between the pre-pulse and the signal under test should be such that the complete leading edge of the signal under test is displayed.

2.5.2.3. Time-difference measurements (PM 3010 only)

The time difference between two separately displayed pulses may be evaluated with the aid of the PM 3010 oscilloscope.
It should be noted, however, that the oscilloscope can only present a stable display of two separate waveforms if the frequency of one waveform is a multiple of the other.
To measure the time difference between the respective edges of two separately displayed signals, connect the signals to the Y input sockets and adjust the Y controls to obtain as large a trace as possible. Then proceed as follows:

1. Rotate the Y POSITION controls to position both traces symmetrically about the centre-line of the graticule.
2. Set the TIME/DIV switch so that the horizontal distance between the measuring points is as large as possible.
3. Rotate the X POSITION control so that one of the measuring points coincides with the nearest vertical graticule line.
4. Measure the horizontal distance between the measuring points.
5. Multiply the measured distance by the TIME/DIV setting and, if the magnifier is used, divide this product by 10.

Example: Assume that the TIME/DIV setting is 10 μs and that the magnifier is used. The measured distance is 2,2 DIV (See Fig. 2.23.).

$$\text{Time difference} = \frac{\text{Hor. distance . TIME/DIV setting}}{\text{magnification factor}}$$

$$= \frac{2{,}2 \cdot 10^{-5}}{10} = 2{,}2 \ \mu\text{s}$$

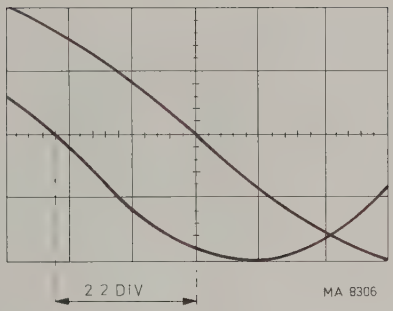


Fig. 2.23. Dual-trace time measurement

2.6. TROUBLE SHOOTING HINTS

2.6.1. Pilot lamp does not light up

When a battery PM 9397 is used to power the instrument and the pilot lamp does not light up after switching on, this indicates that the battery voltage is too low and the battery needs recharging.

If an a.c. adapter PM 9398 is used and the pilot does not light up, you must check whether the trouble exists in the a.c. adapter or in the oscilloscope circuitry, supposed, of course, that the mains voltage is present.
To locate the trouble, the a.c. adapter should be taken out of the instrument and an external 6 V voltage should be applied to the power terminal strip in the battery compartment (+ to the press-button, — to the stud, Fig. 2.24.).
If the pilot lamp lights up now and a current of approx. 0,5 A is drained from the external source, the instrument is normal and the trouble lies in the adapter.
If the pilot lamp still does not light up, the oscilloscope circuitry must be checked, starting with the power supply section.

Fig. 2.24. Polarity of terminals

2.6.2. Pilot lamp lights up, but there is no trace

If the pilot lamp lights up and a trace does not appear, rotate the INTENS control fully clockwise and depress the LEVEL control for automatic triggering. Rotate the Y POSITION control and check whether a trace appears on the screen. If it does the instrument is normal.
If a trace does not appear, rotate the X POSITION control.
A bright dot may appear. If it does, the trouble is in the horizontal deflection system.
If no dot appears, the trouble may be in the power supply, the c.r.t. circuit, the vertical deflection system or the horizontal deflection system.

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